THE SIDEREAL MESSENGER,

CONDUCTED BY WM. W. PAYNE,

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

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THE FIRST COLLEGE OBSERVATORY IN THE UNITED STATES.

JAMES L. LOVE.*

FOR THE SIDEREAL MESSENGER.

An Astronomical Observatory begun at the University of North Carolina in 1831 and completed in 1832 has, for some reason, remained unnoticed by historians of astronomy. Professor Loomis, in his "Progress of Astronomy," edition of 1850, gives to Yale College the credit of the first purchase of a telescope, in 1828; and to Williams College the honor of erecting the first Observatory in 1836. But the University of North Carolina bought instruments before Yale, and built an Observatory before Williams. Yale College ordered her telescope in 1828, received it in 1830, and placed it in the steeple of one of the buildings, where low windows interfered with its use. Professor Albert Hopkins went to Europe in 1834 to select instruments for Williams College; and his Observatory was ready for use in June, 1838. President Joseph Caldwell went to Europe in 1824 to buy books and apparatus for the University of North Carolina. He laid out $3,234.74 for books and $3,361.35 for apparatus, of which a large part was for astronomical instruments. These were received in 1825-26, and were at first set up in Dr. Caldwell's lecture room; and used in determining, among other things, the first approximate values of the latitude and longitude of Chapel Hill. The foundations of the Observatory were laid in April, 1831; but work was stopped until March, 1832, when it was resumed and kept up until the completion of the building in August, 1832. It was a single-roomed building 15 by 23 feet and about 25 feet high. The first eight feet of the wall were of stone, plastered inside and out, and enclosing

* Associate Professor Mathematics, University of North Carolina.

a low basement slightly excavated. Above this the walls were of brick, terminating in a low parapet round the top. The first floor was several feet from the ground, and was reached by a flight of steps on the eastern face of the building. The roof was a nearly flat double floor, caulked and pitched. A steep stairway inside the building led up to this upper floor. Two pillars of masonry rose up through the interior, one of them terminating just above the first floor and bearing the transit instrument, and the other rising above the roof and bearing the altitude and azimuth instrument on its top. A low tower with doors in opposite faces was constructed to protect the altitude and azimuth instrument. This tower was placed on a railway and was moved back and forth by rope and windlasses. Its top was flat and was reached by a light ladder. To furnish a range for the transit, which was inside the building, a slit several inches wide was made across the roof and down into the north and south faces of the walls, in the plane of the meridian. Shutters were constructed to close up this slit when the transit was not in use.

The building was on a low hill just outside the campus. The trees had been cut away so that a sweep of the entire horizon could be made with the altitude and azimuth instrument. This was not a private Observatory. The entire cost of the building ($430), as well as of the instruments, was paid by the University.

The transit instrument was made by Simms of London. Its focal length was 44 inches and its aperture 3 inches. The altitude and azimuth instrument was also made by Simms. Its aperture was 2½ inches and focal length 33. Its horizontal and vertical circles were 20 and 24 inches in diameter, respectively, with two verniers and reading microscopes to each. These circles were graduated on platinum bands to 5 minutes of arc.

The telescope was a small portable one of 2½ inches aperture and 52 inches focal length. It was made by Dollond of London. The astronomical clock was made by Molyneux, with mercurial pendulum. The outfit contained also a reflecting circle made by Harris of London, a sextant, and a Hadley's quadrant.

Observations were made here by Dr. Caldwell and his two

colleagues professors James Philips and Elisha Mitchell, but they were kept up for only a few years, but Dr. Caldwell was the moving spirit of the enterprise. His health begun to fail soon after the building was ready for use; and, after his death in 1835, there was no one here who had time and inclination to push the enterprise on to success. The times were not favorable here in North Carolina, nor any where else in this country, for the establishment of Observatories. Our national Observatory was not authorized by Congress for ten years after this; and even then, its name had to be disguised as that of a "Depot of Charts and Instruments." It was only when some individual enthusiast like Albert Hopkins or Joseph Caldwell, by his personal effort or influence had an Observatory erected, that anything at all was done. Had Dr. Caldwell been in the prime of life, or had there been any successor to his zeal and energy, something excellent would have grown out of this beginning. But Dr. Caldwell's successor in the Presidency of the University, D. L. Swain, was in no sense a scientific man. His studies were in history, law and politics. The Observatory was not fostered by him. The roof began to leak, and it proved so troublesome that the instruments were removed soon after Dr. Caldwell's death; and the wood-work of the building was burnt from some unknown cause about 1838. In a few years the bricks were hauled away and used in building a kitchen, which is in use still! The foundations of the Observatory can be easily traced yet, and there are several persons of the highest character, now living in Chapel Hill, who witnessed observations there in their childhood. All records of observations have been lost; whether during reconstruction days when the University was closed for some years and some of the dormitories turned into stables by negro troops, or before, no one knows.

All the instruments but the reflecting circle and the quadrant are still in the possession of the University; and all are unfit for use except the telescope and clock. The latter still marks time for Chapel Hill. It will be granted, I think, that Dr. Caldwell had a pretty fair nucleus of apparatus to begin his Observatory with. A telescope costing twelve or thirteen hundred dollars was in contemplation, but Dr.

Caldwell's death caused the failure of the whole enterprise before it could be bought.

Dr. Caldwell was a graduate of Princeton, and was called to the Professorship of Mathematics in the University of North Carolina soon after its establishment in 1795. He was afterwards made president. When he died in 1835, he had brought the University up to a position which compared very favorably with older and wealthier institutions. He brought back from Europe in 1824 nearly a thousand volumes of very carefully and intelligently selected books to start a good library with. The apparatus he bought was of the best. He brought to Chapel Hill some of the best talent in the country as members of his faculty. Among them were Professor James Phillips and Dr. Elisha Mitchell, who lost his life in the scientific exploration of the highest mountain east of the Mississippi, a peak of the Alleghany range in western North Carolina now called for him "Mitchell's Peak;" also Professor Ethan A. Andrews, who was called from here to a professorship of Latin in New Haven, Connecticut; and Denison Olmsted, who went from here to Yale.

Dr. Caldwell's efforts to promote science deserved a higher appreciation than they have yet received. Let us hope that he, and the institution he guided so intelligently, may be given the credit they merit for building the first College Observatory in the Union.

Chapel Hill, North Carolina, Oct. 31, 1888.

THE EFFECTS OF ROTATION UPON THE FLUID ENVELOPE OF A REVOLVING SPHERE.*

SEVERINUS J. CORRIGAN.

We can determine the effects of rotation upon any particle situated upon the augmented equatorial circumference or upon any augmented meridian circumference in the same manner and by means of the same equations used in the case above discussed.

The value of p, thus determined, will represent simply a force opposed to gravity and it is the one generally known

* Continued from page 381.

as "the centrifugal force." The equal force at a right angle to it represents an approximately tangential pressure in an eastward direction. It represents the force which, when called into action by the perturbing force of cosmical bodies, becomes, I claim, the prime cause of all the phenomena mentioned at the beginning of this article. The distance *ac* in Fig. 1, through which an unimpeded particle would fall to the "centre of gravity" *c*, may be regarded as representing the whole force of gravity acting upon the particle at *a*. This distance *ac* is the radius of the equatorial circle, and since *p*, or the radial force acting in opposition to gravity, is expressed in terms of this radius, the value of *p* computed from equation (1), by means of the augmented values of *v* and *r*, will represent the "centrifugal force," expressed, as it usually is, in terms of the whole "force of gravity." Performing the operation we find that $p = \frac{1}{291.5}$. As before, there will be an equal force having its origin at the focus *f*, or nearly seven miles below the surface, and directed at a right angle to the former force.

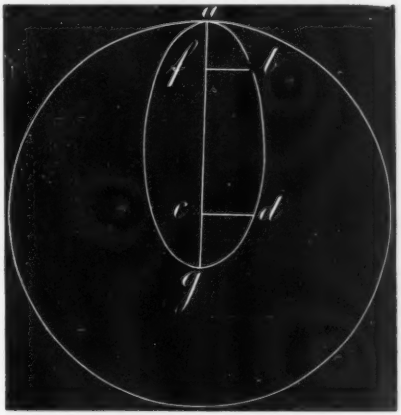


FIG. 1.

If we combine these two forces together, and then their resultant with the whole "force of gravity" by means of the well-known formulæ for the "composition and resolution of forces," we will find that the resultant or apparent gravity will be directed, not normally to the surface, but eastward at an angle *a*, whose value on the equator is 11′47.5″. This angle may also be computed from the equation $\sin a = \frac{p}{r}$; therefore the semi-parameter *p*, may be taken as the measure of this angle.

From equation (1) we see that *p*, and therefore the angle *a*, increase with the distance from the "centre of gravity."

The direction of gravity thus assumes the form of a curved line. All matter attracted to a centre and, at the same time, impressed with a velocity whose direction is not exactly toward the centre, will approach the latter in a curved line, as may be demonstrated by means of equation (1).

Of this action, there are, I think, examples in the "spiral nebulæ," whether these be gaseous or simply star clusters, and it is to it that the sun and the planets, formed by the condensation of nebulous matter toward a centre, owe the motion of rotation upon their respective axes. It thus bears testimony, to a certain extent, to the truth of the nebular hypothesis, taking the latter in a general sense. We see from the above that the "centrifugal force" which will now be designated by m, is $\frac{1}{291.5}$ of the whole "force of gravity." The value of m determined by the ordinary method is $\frac{1}{289.5}$. The small though very important difference between the results determined by the two different methods is due wholly and solely to the fact noted above, that the force acting at a right angle to the radius is *not* a tangential force, as it has been assumed to be in the ordinary method. As demonstrated above the force at a right angle to the radius has its origin, not on the surface, but at the focus, f, nearly seven miles below, and therefore its direction differs from that of a tangent to the surface by 11 47 .5.

I have stated that the compression (taken in the sense $c = \frac{a-b}{b}$) deduced from pendulum vibrations is $\frac{1}{288.5}$, while that derived from arcs of meridian is $\frac{1}{294.0}$, and that the discrepancy has been attributed mainly to local causes affecting the motion of the pendulum. I have also *asserted* that the greater part of the discrepancy was due to a cause entirely different from that assigned. I now purpose to demonstrate the truth of my *assertion*. To do so I have recourse to Clairaut's well-known equation, which expresses the relation between the "centrifugal force" m, the compression e, and the difference between the "force of gravity" at the poles and at the equator, the polar gravity being denoted by g, and the equatorial by g'. This equation is as follows:

$$\frac{g-g'}{g} + e = \frac{5}{2}m.$$

If in this equation we use the value of m, determined by the usual method which does not take into account the inclination of the direction of gravity to the normal, the result for e will be, as stated, $\frac{1}{288.5}$, but if we use the value of m found by my method which does take into consideration this inclination, the result is $\frac{1}{293.5}$.

This can be seen at a glance from the above equation, for if we change m, as we do, by 2 units in the denominator, we change the denominator in the value of e by $\frac{5}{2}$ of the same amount, or by 5 units, so that instead of $\frac{1}{288.5}$ we have $\frac{1}{293.5}$. As has been stated, the value obtained from arcs of meridian is $\frac{1}{294.0}$. The difference between the two determinations represents only 106 feet in the length of the equatorial radius, certainly a remarkable agreement, and one demonstrating the fact of the eastward inclination. The existence of this tendency to eastward pressure can be shown in another manner. Let us consider the particle at a or the *apogee* of the orbit, shown in Fig. 1, and let the following figure show that portion of the orbit lying between the apogee and the end of the semi-parameter at b.

It is evident, from the laws of planetary motion, that the orbital velocity of the particle at a will be increased in passing from a to b; on the equator the direction of the velocity is parallel to the equatorial plane, or eastward, and, as has been shown already, the velocity not only decreases but it also changes its direction with the latitude; becoming at a right angle to the equator in latitude 90°. Therefore, if all the terrestrial particles were free to move, there would be tendency to an excess of angular velocity near the equator, and thus an eastward pressure. In a rigid mass there can be no actual motion, the effect being simply a strain, but in a tenuous fluid, such as the upper atmosphere of the earth, and in the surface matter of the sun, where the particles have comparative freedom, real motion would be the result, and thus differences of angular velocity would give rise to vortices in a manner too obvious to require a lengthy explanation, these vortices being comparable to the eddies of a stream caused by the different rates of motion in different portions of the current. The

FIG 3.

objection may be raised that when the earth or any other cosmical body has assumed its figure, equilibrium will exist, and that there will be no eastward pressure, no difference of angular velocity. This objection might be a valid one, were each cosmical body unaffected by any other, i. e., were there no perturbative action, but so long as the "law of gravity" is in force and neighboring bodies exist and pursue their courses, there can be no equilibrium in the strict sense of the word. Just as the orbits of the planets are affected by perturbation and the planetary velocities caused to vary periodically, so will perturbing bodies tend to cause the orbits and the velocities of the particles of solar, terrestrial or planetary matter to pass through cycles of change. The mode of action of the perturbing force cannot, of course, be explained in detail here, but in a general way. The effect is much the same as that which would be caused by adding to, or subtracting from, the mass of the central attracting body, whose particles are under consideration, the mass of the perturbing body.

Whether the latter mass will be additive or whether it will be subtractive, depends upon the position of the perturbing body, and also of the perturbed particle relative to the "centre of gravity" of the body to which the particle belongs. By relative position I mean not only angular but also linear distance. If we consider the mass of the central body to be, as it were, thus subject to variation, it follows that the value of k^2, used in equation (1), will be subject to variation and therefore, that p, derived from that equation will also vary. It is evident that, since the perturbing force varies in a manner dependent upon the position of the disturbing body relative to the disturbed, the variation of the value of p will be periodic, depending upon the periodic time of the perturbing body. Returning to the consideration of the effects of the difference of *angular* velocity, thus produced upon the particles of any cosmical body, it is obvious, as before stated, that this difference varying as it does with the latitude, will generate vortices in the fluid envelope of any revolving spheroid.

The vortices thus formed may be regarded as bodies distinct from the matter in which they are generated, and as such they will be acted upon by the eastward pressure in the

same manner as is the infinitesimal particle, which has been considered. It is also possible that these vortices will tend to move in orbits around the "center of gravity" of the body upon which they are formed, just as the particle at *a* in Fig. 1 moves, the orbital motion being in the same general direction as is the motion of rotation. In the case of the sun, I have claimed that the sun-spots are such vortices; therefore they should have a *proper* motion in the direction of the sun's rotation, and also this proper motion should be greater the nearer to the solar equator the spots are located. The results obtained by eminent observers of the solar phenomena show that the spots have a *proper* motion such as my hypothesis demands. In the case of the earth, I have claimed that these vortices are the rotating storms, or the cyclones, (the word cyclone being used in this connection in its widest sense), therefore these storms should have a proper motion in the direction of the earth's rotation.

The *general* eastward march of all areas of low barometer, or the storm centres, is an indisputable fact of meteorology.

The periodic variation in the number of sun-spots has been observed to be, apparently, connected with the periodic times of Venus, the Earth, Mars and Jupiter. Since, according to my hypothesis, the sun-spots or vortices are due, mainly, to the perturbing action of the planets, and since the perturbing force varies with the periodic time of the perturbing body, it follows that the period of the vortices or sun-spots must be the same as that of the perturbing body. Since there are a number of these bodies, the result of the action of all may differ somewhat from that produced by any *one*, Jupiter being the largest as respects mass, his effect should be the most noticeable, but Venus being *nearer* the sun, although its mass is much less than that of Jupiter, should give a marked result. The same perturbative action is in force against the revolving particles of the earth. The moon and the sun are the bodies which exert the greatest force upon terrestrial particles, and since the same reasoning applies in the case of the earth as in the case of the sun, it follows that the varying positions of the moon and of the sun must produce variations in the *angular* velocities of the atmospheric particles, and that these varia-

tions will have a periodicity dependent upon the periodic time of those bodies.

The existence of some unknown connection between terrestrial storms and the varying positions of the moon and of the sun, has, for a long time, been surmised. If my hypothesis be true, what has been hitherto a mere surmise becomes an established fact; just as the perturbing planets act upon the solar particles, so do the moon and the sun act upon the atmospheric particles; these latter particles may be regarded as little planets whose orbital velocities the perturbing action of the moon and of the sun tends at certain times to increase, and at other times to retard, increase of velocity producing vortices, areas of low barometer or cyclones, while retardation of velocity causes a setting back and piling up of the atmospheric particles, thus producing areas of high barometer or anti-cyclones.

The sun apparently moves from aphelion to perihelion in six months, and the moon, which from its proximity to the earth produces the greater perturbative effect, moves from apogee to perigee in approximately two weeks. Atmospheric and seismic disturbances having periods corresponding, may therefore be inferred. Furthermore, the perturbative action depends upon the position of the moon and of the sun relative to each other. The two work together at the syzygies, and in opposition at the quadratures, therefore twice in each lunar revolution there should be a maximum effect, and twice in the same time, a minimum; thus it may be seen that atmospheric disturbances varying with the positions of the moon and of the sun, are necessary consequences of the action of the "force of gravity."

By the diurnal revolution of the earth, a terrestrial particle is carried around the globe in one sidereal day; the effect of this change of position relative to the positions of the perturbing bodies, is much the same as if the latter were to perform one revolution in the day; or we may regard the particle as making one orbital revolution in the same time, the perturbing bodies remaining stationary. The perturbative action may then be expressed by the following equation:

$$t = -\frac{k^2 m r}{\Delta^3} . \sin 2\phi \qquad (7)$$

Regarding the moon as the perturbing body, m, k^2, and r

have, in this equation, the same significance as before, Δ represents the distance of the moon and ψ the angle at the earth's centre, between r and Δ. The first member of this equation represents the tangential force, and as such it represents the force which operates to cause variations in the orbital velocity of any particle; hence variations in the production of vortices, areas of low barometer, or storms.

We see from equation (7) that the velocity will vary as sin 2ψ; the action upon any one particle will, therefore, be 0 at the syzygies and at the quadratures, change sign at these points, and give two maxima and two minima half way between them. There should therefore be two maxima and two minima like those above mentioned but having a much shorter period; *i. e.* these effects should occur in one day, as well as in nearly twenty-seven days. I think that there is some evidence tending to show such action, for one of the best known phenomena of meteorology is the "diurnal oscillation of the barometric column," this oscillation having two maxima and two minima in one day. Furthermore, this phenomenon is most marked in the equatorial regions, just as my hypothesis demands that it should be.

The diurnal effect is, of course, very much less than the monthly, because the period is so much shorter, and the variation of the relative distance of the moon, much less. This brings us to the consideration of another question. It may be thought that the perturbing force is too small to produce the known effects; but, even admitting it to be small we must recognize the fact that the elements of time and of mass must be regarded as factors in the problem; a *small* force acting upon a *large* mass for a *long* time may produce momentous results, by virtue of inertia. Although the effect, produced in six hours, may be very small, that generated by continuous action for a week may be very great. It is also to be considered that, under my hypothesis the force exerts its greatest power upon the tenuous particles of the upper atmosphere; the rotary storms should, therefore, have their inception near the upper limit of the atmospheric envelope. The vortical motion may be small at the beginning, but the in-rush and up-rush of air, when the vortex has

been formed, may generate *very* intense action. A very good illustration of this fact may be seen in what is often called the "cyclone" but which is more properly termed the "tornado." The beginning of the vortical motion of the "tornado" can frequently be distinctly seen through the medium of the clouds. The inception of the phenomenon is usually marked by the approach of two clouds toward each other high in the air. These clouds, indicating the movement of the air are seen to take up a rotary motion around a centre; the funnel is then formed, its apex dropping toward the earth. The *angular* velocity of the rotating column increases toward the apex, until it becomes terrific, and the column seems to become a solid mass, which moves in a *general* direction eastward.

The above facts are well known; I cite them only to show how, from a small beginning, intense action may be developed.

The "cyclones proper" or the great storms, probably act much in the same manner. It may be asked, are not variations of temperature, and the other facts of meteorology which have been assigned as the causes of storms sufficient? As to their adequacy I cannot say, but from what has been shown above, I think that the most rational view is that which regards them principally as concomitants, co-effects whose intimate relation to the phenomenon in question has led to their being regarded as causes; they may modify the action, and play a secondary part, but they cannot, I think, be regarded as prime motors.

In regard to the "seismic phenomena," I have claimed that they are due to the fact that a particle of the solid matter of the earth, being acted upon by the same force as is the fluid particle above considered, *tends* to move in an orbit with a varying angular velocity, the variation being due mainly to perturbation.

Since the particle of sold matter has not the freedom of the fluid particle, motion cannot usually result; but since the force, or the tendency to motion must exist, it takes the form of pressure or strain (probably torsional), the giving way of any part of the solid matter, under the stress, causing an "earthquake." It may be inferred that, according to my hypothesis, the "earthquakes" should have a perio-

dicity depending upon the periods of the perturbing bodies, especially of the moon. Some eminent physicists have declared that a study of the records of a great number of earthquakes seems to indicate the existence of such periodicity, but since it is not to the strain alone, but to the *giving way* of the matter under the strain, that the phenomenon is probably due, we should not expect to find so marked a periodicity as in the case of sun spots or terrestrial storms; great strain may often exist without any shock.

Mallet has regarded the phenomenon as due to a tangential force or strain produced by the cooling of the earth's crust. According to my hypothesis it is due to an approximately tangential strain due, not to cooling of the terrestial matter, but to the force already referred to. It is worthy of remark that investigations of a number of earthquakes have disclosed the fact that the seismic force seems to have its focus or origin near the surface of the earth, the depth varying from three to twenty miles. If we now consider the fact that the pressure or force, represented by the semi-parameter *fb* in *Fig* 1, has its origin at the focus of the ellipse, which focus is at a depth of nearly seven miles below the earth's surface the inference that there may be some connection between the two facts, is not, I think, unreasonable. It has been shown that the orbit which a terrestial particle would describe if free, is an ellipse of great eccentricity, and we see from *Fig* 1, that the direction of the elliptic motion is tangential at the surface, but rapidly becomes directed toward the earth's center, so that whatever tendency there may be to eastward orbital motion or pressure it must be exerted near the surface precisely as the "seismic force" is found to act. If my hypothesis be true, a possible cause of *volcanic* phenomena becomes disclosed; for the compression due to the strain and the friction which must be a consequence of any rupture under the strain, cannot but result in the generation of intense heat in the superficial strata of the earth. The infiltration of the superincumbent water or its admission, through ruptures in the surface matter, upon the heated mass, would probably suffice to produce volcanic eruptions. If this view be true, Sir William Thomson's hypothesis of a "solid globe" becomes compatible with the observed volcanic phenomena.

(TO BE CONTINUED.)

THE DEVELOPMENT OF ASTRONOMY IN THE UNITED STATES.*

T. H. SAFFORD, PH. D.

About two hundred years ago Isaac Newton published his famous "Principia"; the English title is "The Mathematical Principles of Natural Philosophy." From that epoch dates modern astronomy; for the book laid down the law of universal gravitation, according to which the motions of the moon and planets are governed. The same law holds good to the remotest bounds of the universe; comets obey it in their journeys into far distant space, and double suns, in many solar systems, circle around each other in obedience to its formula.

From the discovery of this far-reaching law of nature, the most delicate and exact observations became necessary to test it; for from its very essence it must have an exact fulfillment. Observers must now carry their work to the last degree of delicacy; they must study the structure of the human eye to learn what is the highest precision attainable by the sense of sight, when aided by the best optical glasses.

Newton himself had a small observatory at Cambridge (in England), where he was a professor; but it was not to be expected that he himself should watch the heavens nightly. His mighty genius was too fully occupied with his great mathematical problems; among which is to be reckoned the invention, independently of Leibnitz, of the calculus.

Charles the Second, bad man as he was, possessed human sympathy enough to found an observatory, to preserve his sailors from shipwreck. Navigation was then extremely dangerous; there were no guides across the ocean. Such guides were to be found in a knowledge of the motions of sun, moon, and stars, to be gained by the patient labors of astronomers. So the Greenwich Observatory began; the first Astronomer Royal, a contemporary of Newton, was the Rev. John Flamsteed.

In 1705 Edmund Halley found that the great comet of 1862 was periodic, and would return in 1758; it did so

* A discourse read June 25, 1888, to commemorate the 50th anniversary of the dedication of the Hopkins Observatory at Williams College, Williamstown, Mass.

return, its orbit was again calculated by others, and its next appearance predicted for 1835. As we shall see, this last coming of Halley's comet was influential in the foundation of American observatories. Halley's calculations were made to test and exemplify his great master Newton's theory, of which they furnished a brilliant example. Who will not say, when this fine comet returns in 1910, that it furnishes a new proof of the law of gravitation? In fact Newton must be considered the best astronomer of all past ages.

At Flamsteed's death Halley succeeded him as Astronomer Royal; but he was then an old man, and added little to his former reputation. James Bradley, like Flamsteed a clergyman of the Established Church, was Halley's successor; it was he who first made Greenwich Observatory what it now is, the most prominent one, all things considered, in the world. About 1750 he obtained new instruments, and began the great work of his life,—a magnificent series of meridian observations, which is indispensable to all who wish to know anything about the stellar motions, or to follow sun, moon, and planets in their apparent courses. A most eminent living German astronomer has spent many years in recalculating Bradley's observations, and is now publishing his results.

Bradley was followed by Nathaniel Bliss, who was an indifferent observer; and in a few years by Nevil Maskelyne, who was Astronomer Royal for the half-century which began with our colonial troubles and ended with the war of 1812. Maskelyne possessed some eminent qualities as an observer, but lacked others. He discharged an assistant for noting time differently from himself; it was reserved for an abler man to find out that "personal equation" is a universal phenomenon among observers,—that no two observe times exactly alike. The poor fellow was really an excellent assistant. Maskelyne's great service was the establishment of the Nautical Almanac, the sailor's indispensable companion. The French had had something of the kind for many years, however; I have wondered whether John Paul Jones used his enemy's book in guiding his ships across the ocean, or that of our French friends, in a foreign language.

I have premised these few things about English astronomy

as our own was naturally based upon it. We had not yet declared our scientific independence, were in fact thoroughly colonial in our methods of scientific teaching. Harvard received from an English benefactor, Thomas Hollis, the money for the foundation of her professorship of mathematics and natural philosophy; and English text-books were reprinted and used in some of our colleges till within the present century. The teachings of the colleges were probably traditional, and were not based upon independent research; but practical necessities soon required the employment of astronomical observers

If you look at a map of Massachusetts you will perhaps notice the extremely rough way in which the State is divided into counties and townships. Clarksburg, near us, is six miles long from east to west, by two in breadth; Hancock, fifteen long from north to south; Cheshire has twenty-two corners. The boundaries of our counties are extremely irregular lines, and even those of the State by no means plain and simple. All this confusion of landmarks grew out of old-world habits; we have even an "enclave" in Cohasset, which belongs to Norfolk County, although surrounded by part of Plymouth.

Boundary disputes came up everywhere in the colonies; the people of Bennington, New Hampshire grantees, fought the New Yorkers, who in their turn appear to have established an outpost on the Connecticut River. Many colonial grants had been based upon parallels of latitude and meridians of longitude; I was myself called in, fifteen years ago, to assist in determining a Canadian boundary line, which was a continuation of a meridian through Illinois.

In 1767 the proprietors of Maryland and Pennsylvania sent to England for two astronomers to settle the parallel of latitude between the two colonies. In Massachusetts a similar parallel had been wrongly run; to this mistake we owe the inclusion of the village of Williamstown in Massachusetts instead of Vermont. The astronomers who were called in to fix the Pennsylvania boundary were Charles Mason and Jeremiah Dixon; and these were, so far as I know, the first trained observers ever employed in the United States. Mason had been Bradley's assistant at Greenwich; and the German whom I have mentioned has

discovered, by the handwriting in the original books, which observations were made by him, and which by Bradley and the others. He seems to have been an excellent observer. He had afterwards made many scientific journeys, and had done much by calculation to improve the lunar tables. Dixon was of course Mason's assistant, and is less known.

The work done by these two astronomers was the first piece of accurate measurement in this country, and perhaps it included the first parallel of latitude ever run out as a boundary.

It is not easy to cut one's way through the forest, to spend the nights in watching the stars and the days in moving on through the woods; to carry on horse- or mule-back the most delicate instruments, and watch (I can almost say), every step of the beast, to see if he gives the chronometers any jar; to make the most refined calculations under the most difficult conditions. It is easier to deal with mathematical formulæ by a warm fire in a pleasant room, or even to watch the stars in a well-appointed observatory. But practical astronomy of the kind brought here by Mason and Dixon is useful in all distant explorations, and is admirably adapted as a training for young observers. We have since had much of it in this country, and in our scientific development it has been of inestimable benefit.

About the same time an American astronomer, David Rittenhouse, was making a reputation. On the father's side Rittenhouse was Dutch; his family were paper-makers from Arnhem on the Rhine in Guelderland. He was self-educated; had read Newton's Principia and the other necessary mathematics, and taught himself the clockmaker's trade. Those were the days of the tall hand-made clocks, now so much prized as ornaments; and their construction was a matter requiring much skill. In 1767, Rittenhouse, born the same year as George Washington, was in the prime of life, and may have indulged hopes of making the boundary survey for his native State, Pennsylvania. But he was only a colonist; the proprietors employed him in some preliminary rough work, but sent "home" as the phrase is, for their astronomers. It should have been Mason and Rittenhouse, rather

than Mason and Dixon; Mason indeed found America much to his taste, and returned and settled in this country.

In 1769 came the transit of Venus; that phenomenon which occurs twice in a century only, and to most parts of the world is visible but once during that time. Some of us remember it in 1882, when astronomers were sent all over the world; I visited the party sent from Germany to Hartford, Conn., and was much impressed with their less haste (but more speed) than is natural to the American observer. I had previously learned the same lesson from engineer officers in our army. But in 1769 the transit was the only good means of finding the earth's distance from the sun; a distance which has fluctuated between ninety-two and ninety-six millions of miles since my remembrance. It is now pretty well settled as between ninety-two and ninety-three millions, but a hundred and twenty years ago it was rather uncertain. Rittenhouse built a little observatory near his house at Norristown, Pa., and was of great help to others, who observed the transit in and near Philadelphia. The event caused much interest in astronomy, and added to the impulse which it received from Mason and Dixon's labors.

In later years Rittenhouse was much employed as a boundary commissioner; among other work of this kind our own West line along the ridge of the Taconics was settled by his efforts; it has lately been resurveyed and found as well done as was to be expected from his instruments.

He was also an early inventor of the "collimator," a device for obtaining a meridian mark without going far away; it has lately come back from Germany, where it was re-invented, and is now employed in the Field Memorial Observatory.

In general science the two ablest colonial Americans were undoubtedly Benjamin Franklin and Benjamin Thompson. Franklin, as we all know, drew the lightning from heaven, and proved its identity with electricity. His services as a diplomatic agent in France were greatly helped by his scientific reputation; returning to America he was instrumental in founding the two early academies of science, the American Academy at Boston, and the American Philosophical Society at Philadelphia. Both these have done useful work

recorded in their Memoirs and Proceedings. Thompson was so unfortunate as to be a Tory; not a bitter one, but yet enough to make him an exile, and a great loss to his country. He served in the English army, went afterwards to Bavaria, where he laid out the "English Garden," the fine park of Munich—it should have been called the "American Garden"—and then to France. In his peregrinations he was knighted as Sir Benjamin Thompson, and afterwards ennobled as "Count Rumford." In his old age he did not forget his native land, but left a part of his fortune for prizes to American investigators of light and heat, and another part for a Rumford Professorship at Harvard.

After the Revolution the first great astronomer of this country was Nathaniel Bowditch; born in 1773, and dying in 1838, he had the fortune to be brought up and to live in free America. He came of a family of shipmasters; had but few opportunities of education, but gave his whole leisure as a mechanic's apprentice, to learning. When a young man he went to sea as a supercargo, and continued his mathematical studies on long India voyages; he learned Latin and French for the sake of the sciences. When twenty-nine years old he went to the Cambridge commencement; his ship was then wind-bound in Boston Harbor, and he heard to his utter surprise that he was made a Master of Arts.

At that time he had edited for America John Hamilton Moore's Navigation; its errors were so many that he re-wrote the entire book, and published it as "Bowditch's American Practical Navigator." The work became famous, and brought him a modest fortune. By and by he was able to give up his seafaring life and enter on business at Salem, afterwards at Boston; meanwhile he continually corrected and improved the "Practical Navigator," so that it has long been the best book of its kind in the English language.

While successful in business, owing to strict method and sterling integrity, he was able to do much to further astronomical science. He observed eclipses, meteors, comets; calculated the orbits of these bodies, learned German in order to read the writings of Olbers and others on such subjects; and finally translated and published at his own expense the great treatise of Laplace on "Celestial Mechanics," with im-

portant additions from the works of the German astronomers. Meanwhile other French mathematical books of a more elementary character had been translated and published at Cambridge, as well as by the West Point professors. The military school was established early in the century, but received its chief development after 1817. During our Revolution we had employed continental engineers, Kosciuszko among them, and the French Revolution had brought others to this country, some of whom became instructors at West Point. The French mathematics thus supplanted the stiffer English text-books, including Euclid, both at West Point and some of the colleges; and John Farrar, professor at Cambridge, led his pupils pretty far along in these studies.

Among Farrar's students was a young friend of Bowditch's, Benjamin Peirce, who soon showed a profounder mathematical ability than Bowditch himself. Other Bostonians interested in astronomy were Robert Treat Paine, a very enthusiastic and careful observer, who went over sea and land to observe solar eclipses, and determined latitudes and longitudes in many places, especially in Massachusetts, with sextant and chronometers. Simeon Borden made, about half a century ago, a triangulation of the State, which with Paine's latitudes and longitudes, gave a measure of the earth, which is by no means seriously inaccurate, considering the smallness of the instruments, and the moderate size of the territory.

Meanwhile the United States had begun a general survey of its coasts. Early in the century there came hither a Swiss astronomer and geodetic surveyor, F. R. Hassler. He was for a time professor at West Point; he became known as a man of high scientific attainments and practical ability, and began the survey after furnishing a better detailed plan for it than any of his competitors. This work, however, soon lost favor with Congress, was interrupted for years, and begun again in 1832. He was successful in training up an able set of assistants, and was able to make a good beginning of the Survey. Meanwhile the West Point school had educated many promising pupils, and the engineers of the army began to be skilful in carrying on astronomical

and other higher surveys, taking up the work of Rittenhouse and other civilians, and improving on the former methods.

One excellent astronomer among the army officers was James D. Graham, who had much the same characteristics as Paine, whom I have mentioned. Both were admirable sextant observers, and in general, could obtain very accurate results with very moderate instruments. Neither of them felt quite at home with the giant telescopes of modern times.

At Yale College a good telescope of moderate size was procured as early as 1832. In that year and the next occured the great November shower of meteors, which happens two or three times every thirty-three years. The teaching power of Professor Olmsted, the telescope of five inches' aperture, the meteoric shower, and later Halley's Comet, seem to have aroused a good deal of astronomical enthusiasm at New Haven, and for a few years a number of the students turned their attention to astronomy.

The telescope would have done better service had there been an observatory; but it was set up in the tower of a college building, and rolled upon casters over an unsteady floor; few accurate observations were made with it. Of the mathematicians and astronomers graduated in those days, Mason and Stanley died young, Loomis and Lyman are still aged professors at New Haven, but Chauvenet, on the whole the most eminent, never returned to the college. He went into the United States Service as Professor of Mathematics in the Navy, and was one of the most important men at the Naval Academy founded by Secretary Geo. Bancroft. He removed to St. Louis and became head of the Washington University of that city, where he died. Chauvenet was the son of a Frenchman who married in America, and combined in many ways the characteristics of the two nations. From his father he received a careful training in the French language, and his books exhibit much of the elegance of the writers of that nation. His "Spherical and Practical Astronomy" is probably the best book on the subject in any language; I see it quoted abroad as well as at home; it is an inexhaustible store of the best mathematics of the subject.

(TO BE CONTINUED.)

REPLY TO PROFESSOR CRAWLEY'S CRITICISM ON "A NEW THEORY OF SOLAR HEAT AND GRAVITATION."*

J. H. KEDZIE.

For THE MESSENGER.

My attention has just been called to a very candid, courteous and scholarly review, by Professor Crawley, of my book on Solar Heat, Gravitation and Sun Spots. There is no difference between us, and can be none, in regard to the fundamental facts and principles involved; nor can there be any essential difference between us as to the conclusions to be drawn from these facts and principles.

Still the Professor, as might be expected, finds several things to criticise, as some errors and inadvertencies are almost unavoidable.

If I can explain or answer all of these to his full satisfaction, I shall be doing a favor not only to him, but to all truth-loving readers.

I will first state the objections briefly, and then give my replies; indicating the substance of the objections by quotation marks, though not in the language of Professor Crawley.

1. "Spontaneous transformation of heat-bearing waves into world bearing waves or gravitation: Have we any instances of spontaneous transformations?"

I answer,—All transformations of energy are spontaneous, *i. e.* they all take place by virtue of nature's laws and forces, unaided by us, except in the arrangement of the circumstances. Take a supposable case: An insulated cubical rock might receive continuously on *one* side for many hours the intense radiations of a tropical sun. The heat would penetrate into and be distributed through the whole mass, and would ultimately be radiated from all the *six* sides of the rock in a "degraded" or modified form. So the heat waves from the suns must necessarily change in character by diffusion and storage in a constantly increasing number of particles.

2. "As the stars are by no means uniformly sown over the fields of space, the gravitation waves must be much more

* Professor Crawley's Criticism, to which this paper is a reply, was published in October MESSENGER, No. 68.

effective from some directions, the Milky Way, for example, than from the more sparsely populated regions."

I reply,—Do we find the diffused starlight on a moonless night any more intense from the direction of the Milky Way than from other parts of the heavens?

But the case is stronger in respect to the low-pitched waves of gravitation. It is well known, both from observation and mathematical calculations, that the mechanical pressure of the ether, estimated at a low figure as 500 tons to the square inch, though exerted in straight lines of radiation, is, and necessarily must be, equal in all directions. It is, therefore, quite immaterial whether or not the orbs which "people the profundities of space" be evenly or unevenly distributed.

3. "All bodies exposed to the same thermal influences receive heat in proportion to mass, but radiate in proportion to surface.

This is referred to in my book as one of the reasons why the earth has cooled more rapidly than the sun. But if the sun, as claimed in the book, receives his heat at his surface, does he not receive it in proportion to surface and in proportion to mass?"

I reply,—Certainly not. All bodies heated by radiations receive their heat at the surfaces exposed, and the farther progress of the heat inwards is by conduction. Two bodies of the same mass and similarly exposed to the same source of heat will, of course, absorb twice as much heat as one; that is, they will absorb heat in proportion to mass, but they will, of course, receive it in the first place at the surfaces exposed.

4. "In the book it is maintained that *another* reason why the earth has cooled off more rapidly than the sun is that a large portion of the waves of mechanical motion which attack the earth are utilized for the purposes of gravitation and therefore do not change to heat. The sun, being in the center of his system, has little or no gravitative motion relatively to the members of his own system, and therefore all of the waves reaching his surface must turn to heat. The Professor asks: 'Is Mr. Kedzie ready to deny the universal application of the law of gravitation?'"

I reply,—The reader of the book will notice that there, as

here, I have carefully restricted this motionless condition of the sun as related to his own system, and that it has nothing to do with the motion of the sun accompanied by his system in space. There is not the slightest doubt but that our sun, with all of his attendant worlds, is moving grandly through space in obedience to tangential and gravitative forces.

But relatively to his own system, he is almost stationary, and all the waves of which he is the *center*, are and must be turned to heat, while a large portion of the similar waves striking on the outer surfaces of the planets, do not turn to heat, but continue as mechanical motion under the form of gravitation.

I cannot but express my gratification at the learned and forcible manner, far surpassing that of the author, in which Professor Crawley has approvingly outlined the main arguments of the book.

MR. KEDZIE'S THEORY OF SOLAR HEAT.

W. H. S. MONCK, DUBLIN, IRELAND.

FOR THE MESSENGER.

I think Mr. Crawley has done good service in calling attention to this theory, and that whatever becomes of Mr. Kedzie's views on gravitation or on the machinery by which the sun derives a supply of heat from the ether, there is room to construct a good working hypothesis from the residue of the theory. For this purpose I will approach it from a somewhat different point of view.

That there is something in space which absorbs or intercepts light is a theory as old as Olbers and W. Struve. The grounds of it I glanced at briefly in my *Note on the Distribution of the Stars*, which appeared in THE SIDEREAL MESSENGER for January, 1888. The amount of starlight which we actually receive is enormously less than what we would receive from a star system extending to infinity (or to a very great distance, such as, for instance, one million times the average distance of a star of the first magnitude), the average distribution resembling that of our nearer neighbors, and the medium being perfectly transparent. I therefore concluded (as others had previously done), that all the stars

known to us form part of one great cluster, or else that there is a medium in space which intercepts light. In a paper which I read some years ago before the Royal Dublin Society I maintained that this medium, which absorbs or intercepts light, is the ether itself, a theory which I believe is likewise not new.

The reasoning is as applicable to heat as to light. There is, indeed, more uncertainty as to the total amount of star-heat which we receive than as to the total amount of star-light, and if the researches of Pouillet can be relied on, the total star-heat bears a much higher proportion to the sun-heat than the total star-light bears to the sun-light. But I think it must be admitted that the total heat which we receive from the stars is much less than what we would receive from an infinite star system or a finite star system of very large dimensions. We must therefore choose between a contracted star system and a loss of light and heat in transmission.

But if light and heat are lost in transmission, what becomes of them? For they can only pass into some different form of energy. Light may indeed be intercepted by opaque bodies, but in such cases it is either reflected or absorbed, and if absorbed is certain to reappear in the shape of non-luminous heat. The intervention of opaque bodies could make but very little difference in the total star heat since each of these opaque bodies would become a new center of radiant heat. A loss of star-heat therefore implies that the heat lost has passed into some other form of energy. Mr. Kedzie seems to me to have very little grounds for identifying this new form of energy with gravitation, but may not his hypothesis be rectified by speaking of it as simply a new and unknown form of energy?

Now we come to another point on which Mr. Kedzie and his critic seem to have laid sufficient stress. The sun and stars are giving out, and no doubt have been giving out for ages, much more heat than they receive back *as heat* from the ether. Notwithstanding this we have no reason to believe that they are cooling. Indeed geological evidence rather indicates that the sun has not become materially colder for several millions of years. But if they are not getting colder there must be something which maintains

their heat. No satisfactory explanation has been given as to what this something is. Now we find that on the assumption of an infinite or very extensive universe they are surrounded by a medium which contains an immense amount of transformed heat, and if we suppose that the sun and stars possess the power of restoring this transformed heat to its original character, the mystery of The Fuel of the Sun is solved; (though, of course, the solution is only a partial one until we have ascertained the nature of the transformation and the means of restoration).

If the truth of such a hypothesis cannot be directly tested, it is nevertheless to a large extent susceptible of confirmation or refutation by observation, and this remark may be extended to Mr. Kedzie's views on gravitation. If gravitation is transmitted by the ether the obvious consequence seems to be that gravitation travels. The ether may have different rates for the transmission of different kinds of energy and gravitation may travel faster than light or heat; still it is probable that if it travels the effect produced on very distant bodies like Neptune or Halley's comet will show perceptible deviations from those computed on the usual assumption of instantaneous transmission. The problem is one worthy of the attention of mathematical astronomers, especially when we consider Professor Asaph Hall's dissatisfaction with the law of gravitation in the stellar regions. May not the cause of this dissatisfaction be that the action of gravity is not instantaneous?

Sunspots have been comparatively few during this year but during the month of November there have been two groups containing spots of considerable size. One was noticed near the east limb of the sun Nov. 5, and disappeared behind the west limb Nov. 17. The second group was noticed first Nov. 13, a little way from the east limb. Both of these groups changed rapidly and developed into large single spots. If they continue, the first should reappear on the east limb about Dec. 1, and the second about Dec. 9. A few photographs of the sun have been taken at Carleton College Observatory showing these spots and the granulation of the solar surface fairly well.

XUM

CURRENT INTERESTING CELESTIAL PHENOMENA.

THE PLANETS.

Mercury will be at superior conjunction with the sun Dec. 28, and so will not be in favorable position for observation before the middle of January, when he will be "evening star." He will be in conjunction with Jupiter, 1°08′ south, Dec. 16, and with the moon, 2°34′ south, Jan. 1 at 8*h* 12*m* P. M., central time.

Venus has no doubt been easily recognized by most of our readers during the past month, being so beautifully brilliant in the southwest in the evening twilight. The diameter of Venus' disk is now 14″ and is gradually increasing. Her phase is gibbous, about 0.8 of the disk being illuminated. Although the phase is decreasing the planet is approaching the earth rapidly, so that the increased size will more than compensate for the loss of illuminated area of the disk. The distance of Venus will be equal to the distance of the sun on Jan. 7, the diameter on that date being 17.2″ and the illuminated area of the disk 0.693. Venus will be in conjunction with Mars Jan. 2, 6:47 A. M., the latter being 40′ north of the former; in conjunction with the moon Jan. 4, 5:44 P. M., 1°28′ north. Her course among the stars will be toward the east and north for several months, the position becoming better and better for observation until April. Observers should look carefully and persistently for permanent markings of any kind, make careful drawings and note exact times of each for future study.

Mars continues to set a little later each night and is increasing in declination, so that he would be in more favorable position for observation were it not for his increasing distance, which, on January 15, will be twice that of the sun. He may be found among the faint stars of Capricorn, almost on a line between Altair and Fomalhaut. The conjunction with Venus has been spoken of. Mars will be in conjunction with the moon, 2°04′ north, Jan. 4 at 4 P. M.

Jupiter will be behind the sun so that he cannot be seen.

Saturn is in Leo, not far from Regulus, and may be easily recognized by his steady yellow light. The inclination of the plane of the rings to the line of sight is much less than

it was last year, being now only 13°.5. The angle of inclination is now increasing slowly and will reach 16.6° in April, after which it will decrease rapidly for several months. The angle of the line joining the sun and the planet from the plane of the rings is about 15°, so that we are looking at the rings at about the same angle at which the sun is shining upon them. The major axis of the outer ring is about 44″ and the minor axis 10″. The diameter of the planet is 18″. We give this month the central times of the elongations and conjunctions of the two brightest of the satellites, Japetus and Titan, and the eastern elongations of Rhea, Dione and Tethys. The times of western elongation may be easily found by taking the middle time between two successive eastern elongations, and the intermediate positions of the satellites may be easily estimated. Hyperion is too faint and Enceladus and Mimas too near the planet to be seen except with telescopes of very high power.

Uranus is in Virgo about 3° north of Spica. He will be in quadrature with the sun Jan. 11.

Neptune is in Taurus about 5° south of the Pleiades. He will be in conjunction with the moon, 2° 26′ north, Dec. 15, 9:33 P. M., and again 2° 33′ north, Jan. 12, 3 A. M.

MERCURY.

	R. A. h m	Decl.	Rises. h m	Transits. h m	Sets. h m
Dec. 25	18 11.8	−24°56′	7 37 A. M.	11 53.1 A. M.	4 09 P. M.
Jan. 5	19 30.2	−23 56	8 07 "	12 28.1 P. M.	4 49 "
15	20 40.9	−20 19	8 20 "	12 59.1 "	5 38 "

VENUS.

Dec. 25	21 12.9	−18 09	10 05 A. M.	2 53.7 P. M.	7 42 P. M.
Jan. 5	22 03.8	−13 35	9 53 "	3 01.2 "	8 10 "
15	22 47.5	− 8 52	9 37 "	3 05.5 "	8 34 "

MARS.

Dec. 25	21 25.2	−16 24	10 10 A. M.	3 06.1 P. M.	8 02 P. M.
Jan. 5	21 58.6	−13 28	9 47 "	2 56.3 "	8 05 "
15	22 28.3	−10 36	9 25 "	2 46.5 "	8 08 "

JUPITER.

Dec. 25	17 21.5	−22 46	6 36 A. M.	11 03.0 A. M.	3 30 P. M.
Jan. 5	17 32.1	−22 55	6 04 "	10 30.3 "	2 56 "
15	17 41.4	−23 01	5 32 "	9 57.2 "	2 23 "

SATURN.

Dec. 25	9 30.0	+15 53	8 00 P. M.	3 08.8 A. M.	10 17 A. M.
Jan. 5	9 27.8	+16 06	7 14 "	2 23.3 "	9 33 "
15	9 25.1	+16 20	6 31 "	1 41.4 "	8 52 "

URANUS.

Dec. 25	13 20.6	− 7 49	1 31 A. M.	7 03.6 A. M.	12 36 P. M.
Jan. 5	13 21.5	− 7 55	12 48 "	6 20.3 "	11 52 A. M.
15	13 22.1	− 7 58	12 10 "	5 41.5 "	11 13 "

NEPTUNE.

	R. A. h m	Decl.	Rises. h m	Transits. h m	Sets. h m
Dec. 25	3 52.9	+18°30′	2 12 P. M.	9 32.6 P. M.	4 53 A. M.
Jan. 5	3 52.0	+18 27	1 28 "	8 48.2 "	4 08 "
15	3 51.4	+18 26	12 48 "	8 08.5 "	3 29 "

THE SUN.

Dec. 20	17 57.2	−23 27	7 35 A. M.	11 58.2 A. M.	4 21 P. M.
25	18 19.4	−23 23	7 37 "	12 00.7 "	4 24 "
30	18 41.6	−23 06	7 38 "	12 03.2 "	4 28 "
Jan. 5	19 08.0	−22 32	7 38 "	12 05.9 "	4 34 "
10	19 29.9	−21 51	7 37 "	12 08.1 "	4 39 "
15	19 51.4	−20 59	7 34 "	12 09.9 "	4 45 "

Occultations Visible at Washington.

Date.	Star's Name.	Magnitude.	IMMERSION. Wash. Mean T.	IMMERSION. Angle f'm N. P't.	EMERSION. Wash. Mean T.	EMERSION. Angle f'm N. P't.	Duration.
			h m	°	h m	°	h m
Dec. 16	ζ Tauri	5½	12 26	345	Star 5.7′ N. of moon's limb.		
24	ν Virginis	4	12 59	46	13 26	1	0 27

No occultations will be visible at Washington during January except two or three very early in the evening twilight or late in the morning. A few will be visible in other parts of the United States but we have not time to make the calculations necessary in order to give the times. It is known, of course, to most students of astronomy that the time of an occultation varies with position of the observer upon the earth, because of the parallax of the moon. We give the Washington mean times of occultations at Washington. At other places the times will differ not only by the difference in longitude, or the difference in standard time used, but also by a certain interval of time, varying from 0*m* to 30*m* or more, depending upon the difference in latitude and longitude and upon the apparent distance of the star from the center of the moon's path.

Ephemeris of Variable Stars of the Algol Type.

[*Approximate Central Times of Minima; from Astronomical Journal, No. 182.*]

d	h			d	h	
Dec. 15	8 P. M.	Y Cygni.		Dec. 24	7 P. M.	Y Cygni.
18	4 P. M.	R Canis Maj.		26	10 P. M.	Algol.
18	8 P. M.	Y Cygni.		27	6 P. M.	R Canis Maj.
19	5 P. M.	U Cephei.		27	7 P. M.	Y Cygni.
19	7 P. M.	R Canis Maj.		28	9 P. M.	R Canis Maj.
20	10 P. M.	R Canis Maj.		29	4 P. M.	U Cephei.
21	7 P. M.	Y Cygni.		29	7 P. M.	Algol.
22	1 A. M.	R Canis Maj.		29	12 midn.	R Canis Maj.
24	1 A. M.	Algol.		30	7 P. M.	Y Cygni.
24	5 P. M.	U Cephei.		31	3 A. M.	R Canis Maj.

Phases of the Moon.

	Central Time. d h m
First Quarter	Dec. 10 12 46 A. M.
Full Moon	" 18 4 41 "
Last Quarter	" 26 12 00 "
New Moon	Jan. 1 3 08 P. M.
First Quarter	" 8 6 41 "

Elongations and Conjunctions of Saturn's Satellites.

[*Central Time; E = Eastern elongation, W = Western elongation, S = Superior conjunction, I = Inferior conjunction.*]

JAPETUS.

d		d	
Dec. 19,	S	Jan. 9,	E

TITAN.

d h		d h		d h	
Dec. 16, 1 P. M.	I	Dec. 28, 12 M.	E	Jan. 8, 10 A. M.	S
20, 1 P. M.	W	Jan. 1, 11 A. M.	I	12, 9 A. M.	E
24, 1 P. M.	S	5, 11 A. M.	W		

RHEA.

d h		d h		d h	
Dec. 15, 7.9 P. M.	E	Dec. 29, 8.9 A. M.	E	Jan. 11, 9.9 P. M.	E
20, 8.2 A. M.	E	Jan. 2, 9.2 P. M.	E		
24, 8.5 P. M.	E	7, 9.6 A. M.	E		

DIONE.

d h		d h		d h	
Dec. 17, 3.2 A. M.	E	Dec. 28, 2.0 A. M.	E	Jan. 8, 12.5 A. M.	E
19, 8.9 P. M.	E	30, 7.7 P. M.	E	10, 6.1 P. M.	E
22, 2.6 P. M.	E	Jan. 2, 1.3 P. M.	E	13, 11.7 A. M.	E
25, 8.3 A. M.	E	5, 6.9 A. M.	E		

TETHYS.

d h		d h		d h	
Dec. 15, 7.2 A. M.	E	Dec. 26, 2.9 P. M.	E	Jan. 6, 10.7 P. M.	E
17, 4.5 A. M.	E	28, 12.2 P. M.	E	8, 8.0 P. M.	E
19, 1.8 A. M.	E	30, 9.5 A. M.	E	10, 5.3 P. M.	E
20, 11.1 P. M.	E	Jan. 1 6.8 A. M.	E	12, 2.6 P. M.	E
22, 8.3 P. M.	E	3 4.1 A. M.	E	14, 11.9 A. M.	E
24, 5.6 P. M.	E	5 1.4 A. M.	E		

Comet 1888 e, Barnard. Herr Berberich of Berlin has computed the following approximate ephemeris of this comet for the remainder of its apparition (*A. N.* 2862):

Date. Berlin Midnight.		α	δ	log δ	Light.
1888 Nov.	25	43°44′	− 4°58′	0.038	11.9
Dec.	27	6 56	− 7 32	0.217	6.1
1889 Jan.	28	356 49	− 5 26	0.373	3.1
March	1	354 28	− 2 53	0.449	2.0
April	2	353 33	− 0 25	0.461	1.8
May	4	350 47	+ 1 41	0.418	1.8
June	5	341 46	+ 2 51	0.331	2.1
July	7	320 15	+ 0 35	0.252	2.6
August	8	292 37	− 4 48	0.300	1.7
Sept.	9	277 20	− 8 45	0.446	0.7
Oct.	11	273 12	−11 13	0.559	0.4

The unit of light is the brightness of the comet when discovered on Sept. 2, 1888. The theoretical brightness again

becomes unity about Sept. 1, 1889, so that we may expect to observe this comet for at least a year. An ephemeris for the present month will be given later.

Recent Showers of Meteors.

Continued from Sidereal Messenger, December, 1887, page 356.

Epoch of Shower.	Night of Max.	Radiant Point. R. A. Dec.	No of Meteors.	Appearance.
1887.		° °		
November 14.	Nov. 14.	150+22	7	Swift, streaks, Perseids.
November 14–23.	Nov. 23.	132+31	5	Swift, streaks.
November 14–23.	Nov. 23.	194+67	7	Swift, streaks.
November 23.	Nov. 23.	157+49	5	Swift, streaks.
1888.				
July 8.	July 8.	3+49	6	Swift, streaks, Perseids.
July 8–12.	July 12.	310+79	5	Small, short, swift.
July 11–13.	July 12.	28+30	5	Swift, streaks.
July 11–13.	July 13.	319+22	6	Rather swift.
August 2.	Aug. 2.	35+54	14	Swift, streaks, Perseids.
August 5.	Aug. 5.	42+57	11	Swift, streaks, Perseids.
August 8.	Aug. 8.	42+57	20	Swift, streaks, Perseids.
August 13.	Aug. 13.	52+57	13	Swift, streaks, Perseids.
August 2–13.	Aug. 2.	312+15	5	Bright, swift.
August 13–14.	Aug. 13.	8+33	5	Swift, streaks.
August 8–13.	Aug. 13.	23+36	5	Swift, streaks.
August 5–13.	Aug. 13.	104+79	5	Very short, swift.
Aug. 29–Sept. 7.	Aug. 30.	313+65	6	Short, swift.
Aug. 29–Sept. 10.	Sept. 6.	354+67	6	Rather swift.
September 6–7.	Sept. 7.	48+63	5	Swift, streaks.
September 6–9.	Sept. 9.	33+54	5	Swift, streaks.

Though some of these radiant points were decidedly feeble and furnished only five or six shooting stars, I think they may be relied upon.

On July 8 I observed a very definite shower of streak-leaving meteors which I believe to have represented a very early display of the Perseids. Allowing for the displacement in the apparent radiant the centre at 3°+49° falls just where the shower might be expected on July 8 if visible so early as that. In 1885, July 11—14, I saw a shower of similar meteors from the point 11°+48° and there is no doubt that these radiants, situated during the first half of July near the head of Cassiopeia, are formed by meteors which are really the precursors of the great August display and are identical in their origin with that well known system.

At its return in 1888, the Perseid shower was not very conspicuous; its meteors were far less numerous than in some previous years. It furnished a brilliant fireball on the night of Aug. 13, 1888 11*h* 33*m* *G. M. T.* which gave a flash like vivid lightning, and left a streak for three minutes. It was well observed at Bristol and Leeds. This fine meteor appeared over the county of Yorkshire and fell from heights of 78 to 47 miles. Its streak was 18 miles long and situated at heights of 59 to 47 miles. W. F. DENNING.

Bristol, England, Oct 24, 1888.

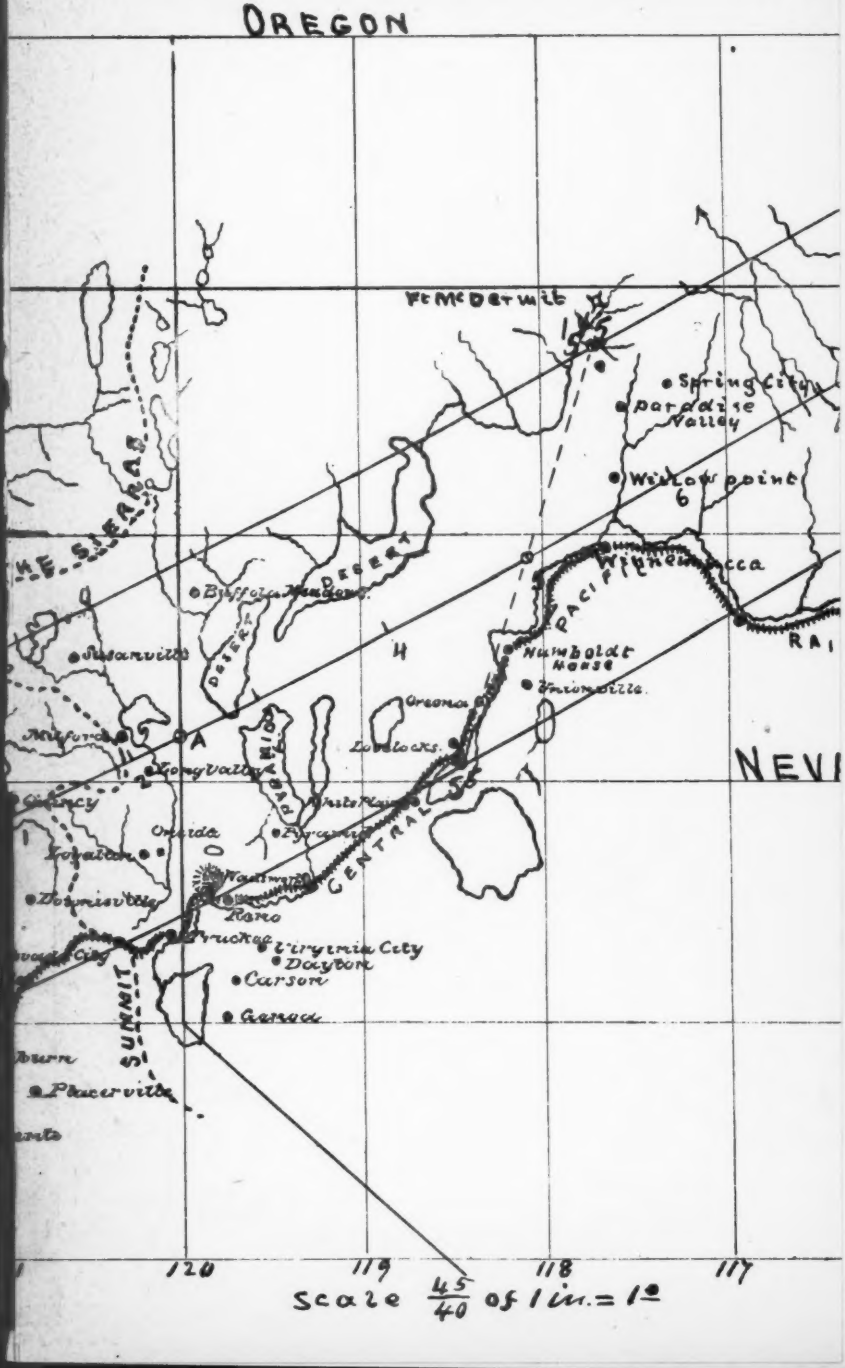
Total Solar Eclipse of Jan. 1, 1889, will be observed by various parties from the United States and possibly some parties from foreign countries. We present herewith a map of a portion of the path of totality which probably will be of most interest to our readers. We are indebted to Engineer C. W. Irish, of Reno, Nevada, for the accompanying map and all points of local interest that we are able to give. The shadow of the moon will cross the west line of Nevada at the town of Verdi, and its width on the boundary will be 100 miles, the middle of the path being at a point 32 rods north of the 124th mile post of the Central Pacific railway line. The south edge of the shadow will pass about half way between Reno and the highest point of Peavine mountain. Thus Reno will be just outside the shadow. The center of the path will be about six miles north of Winnemucca and 29½ miles north of Tuscarora. The south edge of the path will pass north of Wadsworth and south of Pyramid, Lovelocks and Humboldt House. The north edge of the path will pass north of Buffalo Meadows, Willow Point, Paradise Valley, Spring City, Willow Creek, Cornucopia and White Rock, and will pass ten miles south of Ft. McDermitt.

In California, Susanville will be 14½ miles north of the center of the shadow and Quincy three miles north of it. Nevada City will be thirteen miles north of the south line of the path. All the towns named are inside the shadow path, as are Loyalton, Oneida, Long Valley, Milford, and all the settlements about Honey lake. All places in or near the center of the path will be in darkness two minutes of time. All those at the edges of the shadow will see the sun

XUM

PATH OF MOON'S SHADO

43
42
41
40
39
38
PACIFIC OCEAN
CALIFORNIA
IX
IX OF THE SIERRAS
Red Bluff
Chico
Marysville
Oroville
Nevada City
Auburn
Placerville
Sacramento
Woodland
Fairfield
Vallejo
Benicia
Martinez
Oakland
San Francisco
Alameda
San Leandro
Hayward
San Jose
Santa Cruz
Watsonville
Gilroy
Hollister
Salinas
Monterey
Pacific Grove
Santa Cruz
Capitola
Aptos
Soquel
Los Gatos
Saratoga
Mountain View
Palo Alto
Menlo Park
Redwood City
San Mateo
Burlingame
San Francisco
Oakland
Alameda
Berkeley
Richmond
San Rafael
Petaluma
Santa Rosa
Healdsburg
Ukiah
Lakeport
Clear Lake
Williams
Colusa
Yuba City
Marysville
Oroville
Chico
Red Bluff
Susanville
Quincy
Downieville
Nevada City
Auburn
Placerville
Sacramento
Woodland
Fairfield
Vallejo
Benicia
Martinez
Oakland
San Francisco


OREGON
Ft McDermitt
Spring City
Paradise Valley
Willow point
Winnemucca
Humboldt House
Unionville
Oreana
Lovelocks
Virginia City
Dayton
Carson
Genoa
Reno
Truckee
Dennisville
Placerville
SUMMIT
CENTRAL
DESERT
NEVI
120
119
118
117
Scale 45/40 of 1 in. = 1°

AN. 1, 1889.

43° 20'
Unsettled Country
Mountain
Wells
Point
Tuscarora
Tacoma
Toano
Halleck
Ft. Halleck
RAILROAD
NEVADA
UTAH
C.W.I. Del.
Reno Nev.
117
116
115
114
113

momentarily eclipsed. The eclipse will begin at about 1:52 P. M. at Quincy, 1:53 at Honey Lake and 1:54 at Winnemucca. The shadow travels a northeast course across the state, leaving it at the northeast corner. Mr. Irish very kindly offers to furnish further information concerning localities in the path of the eclipse which observers may desire to know.

The points that may profitably receive observers' attention are:

1. Times of the four contacts and the direction of the line joining the cusps during the partial phases.
2. Search for intra-mercurial planets.
3. Observation of fringes which show themselves at the beginning of totality.
4. Photometric measurement of the intensity of light at different stages of the eclipse and during totality.
5. Telescopic observations of the details of the prominences and of the corona.
6. Spectroscopic observations of the lower atmosphere of the sun, prominences and the corona.
7. Observations with the polariscope upon the polarization of the light of the corona.
8. Photography both of the partial phases and of the corona.

The above points are those suggested by Professor Young in his new astronomy.

From recent letters we learn that Charles Burckhalter, of Chabot Observatory, will be at the head of a party of twenty amateur photographers who purpose to try their skill in getting pictures of the January eclipse phenomena. Mr. Burckhalter will use his 10½-inch Newtonian reflector.

New Minor Planets. No. 279 was discovered by Palisa Oct. 25, and noticed in last issue. No. 280 was found Oct. 29 by Palisa. No. 281 was found by same person Oct. 31. *The Astronomical Journal*, No. 184, gives the wrong number, we think, to the planet discovered Oct. 31. It should be 281 instead of 280. So says the *Tietjen* circular, No. 330.

EDITORIAL NOTES.

Volume VII of this publication is completed, and consequently a large number of subscriptions expire with this issue. In such cases a printed blank containing a request for renewal or discontinuance is enclosed in the current number.

It will save unpleasant irregularity if subscribers who receive enclosed printed blanks will promptly notify the publisher that the continuance or discontinuance of this journal is desired for the ensuing year, if this has not already been done.

Some persons having Vol. IV of this publication may find that the title page is wanting, as it was issued separately. Such wanting leaf will be mailed to any one on application.

Professor George Davidson, now of Buena Park, Los Angeles, California, has prepared a large ready blue print map showing the path of totality of the solar eclipse of Jan. 1, 1889, for California and Nevada, also a chart to exhibit the stars and planets to the 6th magnitude within ten or fifteen degrees of the sun. It is to be regretted that the duties of his position in Coast Survey work make it impossible for him to observe in the time of totality.

The Transparency of the Ether. In the first number of the "University Studies," published by the University of Nebraska, Professor D. B. Brace has an interesting article with the above title. Dr. Brace treats the subject mathematically and deduces the equations for the amplitude of luminous vibrations on three suppositions: 1. That the ether has viscosity; 2. That it has imperfect elasticity; and 3. That the diminution of the amplitude is of the character of that observed in solid bodies. The resulting equations are elegant and interesting. A discussion of them shows that, in any of the cases, the absorptive effect would be to give a relative predominance to the red end of the spectrum and that, consequently, if there is any absorption the more distant stars should be more reddish than the nearer, as the

eye is quite sensitive to a small admixture of red in white and as it fails to recognize that the fainter stars are redder than the brighter ones, the author concludes that the absorption is inappreciable even for the most distant stars. His final conclusion is that "either the universe must be finite or, if infinite in extent, the average density of distribution of bodies outside our own system must be exceedingly small, as otherwise the sky would appear of a uniform brightness, approximating that of the sun." H.

Orbit and Ephemeris of Barnard's Comet (Oct. 1888) by J. M. Schaeberle, Astronomer of the Lick Observatory. [*Communicated by the Director*]. From Mr. Barnard's observations of Oct. 31, Nov. 2 and Nov. 4, I have computed the following orbit and ephemeris of this comet:

$$\begin{aligned} T &= \text{Sept. } 9.4475 \\ \omega &= 267^\circ\ 9'.9 \\ \Omega &= 137\ 52\ .0 \quad \text{Apparent Equinox.} \\ i &= 45\ 52\ .6 \\ \log q &= 0.04984 \end{aligned}$$

$$\text{Middle Place} \begin{cases} o-c \\ \Delta\lambda \cos\beta = -0'.2 \\ \Delta\beta = +0'.2 \end{cases}$$

$$\text{Heliocentric Coördinates} \begin{cases} x = r[9.94271] \sin(144^\circ 57'.7 + v) \\ y = r[9.99009] \sin(\ 48^\circ\ 8'.5 + v) \\ z = r[9.72089] \sin(297^\circ 40'.5 + v) \end{cases}$$

Assuming that the above orbit is approximately correct, I find that at the time of perihelion passage the comet was in R. A. $10^h\ 30^m$; Decl. $-21^\circ 44'$, and the light less than twice as bright as it was at the time of discovery. The comet will continue to decrease in brightness, although for several weeks to come its distance from the earth will keep on diminishing. On Dec. 5 and Dec. 25 the computed light will be 0.68 and 0.60 respectively; the light for Nov. 3.5 being unity.

The Photographic Chart of the Sky. The second fasciculus of the "Bulletin of the Permanent International Committee for the Photographic Execution of a Chart of the Sky" has recently come to hand and contains much interesting matter. In the opening chapter the president of the committee,

Admiral Mouchez, reports that the seven instruments being made by Gautier will be finished by the beginning of next year, 1889, and the same will be true with regard to those being constructed by other makers. To the fourteen Observatories already known as certain to take part in the work, must be added the three English Observatories, Greenwich, Cape and New Zealand. Dr. Vogel, of Potsdam, has solved perfectly the question of the best form of a *reseau* or reticule to be used, and will make and verify them for 100 francs (about $25) each. M. Champigneulle is pursuing, with satisfactory results, his experiments with the vitrification of plates to make them unalterable with the time. The Messrs. Henry find the American "Seed" plates, sent them for experiment by Professor Pickering, to be remarkably superior, both in sensitiveness and uniformity of film, to any others which they have tried. These plates will reduce, by half, the time of exposure and consequently the time necessary for the execution of the chart. The president suggests that a reunion of the committee is necessary and that the World's Exposition of 1889 at Paris will afford a very favorable opportunity; that it would be well to place the date of the meeting very near to that of the Astronomische Geselschaft at Bruxelles, in 1889. He also refers at some length to the project, proposed by Dr. Gill in the first number of the Bulletin, in regard to the creation of an International Bureau for the measurement of the plates, in order to construct a catalogue of stars down to the 11th magnitude; which project has met with considerable opposition on the part of certain astronomers, who maintain that the Congress did not sanction the construction of such a catalogue but only the taking of certain plates in such a manner that such a catalogue might be possible. Admiral Mouchez maintains that the Congress did vote the construction of the catalogue and that the method proposed by Dr. Gill is the most economical for carrying out the will of the Congress. In the next paper Dr. Vogel gives the results of his experiments on the form of reticule and the distortion of the film. He finds that the average distortion in a distance of 65*mm* or 1° amounts to about 0.006*mm* or 0.36″. If then the distance between the lines of the reticule be made only 5′, the errors resulting from distortion will be reduced to 0.03″, which is insignificant.

Dr. Capteyn discusses a method of measuring the plates parallactically so as to obtain the R. A. and Decl. of stars directly. Dr. Gill accepts Dr. Capteyn's method as a modification of his own and enters into a discussion of the details of the method and the reduction of the measures. Then follows Professor Pickering's report of photometric observations in progress at Harvard. A catalogue of 1,000 stars situated within 1° from the pole, is almost ready for printing. The discussion which accompanies it comprises the comparison of effects produced in taking photographs of stars by points or traces, in varying the aperture, the duration of exposure or the velocity with which the image is displaced upon the plate. All the stars of the Pleiades have been examined in various ways; also a list of 1,000 stars near the equator. He proposes to select groups of comparison stars at intervals of 5° in declination and 40*m* in right ascension, including stars from the 9th magnitude down to the limit of visibility, and to compare these by eye and by photography.

Several letters follow, discussing points of minor importance. The Messrs. Henry think that plates giving a field 3° square can be employed with accuracy. On the scale which was adopted by the Congress 3° would be 18 centimeters, or about 7 inches. Dr. Gill thinks that plates 2° square would be preferable, owing to the greater ease of reductions if the zones overlap 1° rather than 1½°.

Kepler's Problem. The following extract from the report of the meeting of the "Astronomische Gesellschaft," held at Strassburg, Sept. 22-24, 1881, published in *Copernicus*, Vol. I, p. 200, is worthy of reproduction for the benefit of students and all others engaged in the calculation of orbits:

"Professor Peters also showed how Kepler's equation

$$E = M + e \sin E$$

could be solved by the mere aid of ordinary logarithmic tables more rapidly than by using even the most extensive auxiliary tables. For a five-place computation *log e* in minutes of arc was written down; then with any approximate value of E (say $E = M$) *log e sin E* was mentally computed, and *e sin E* added to M, thus giving a closer approximation to E. In practice one finger of the left hand is inverted in the table at *log sin E*, while another finger retains the place of *e sin E* in the logarithms of numbers."

JOHN TATLOCK, JR.

Last Observations of Comets. In compliance with your request that astronomers give you their last observations of comets, I send the following brief account of the supposed observation of Comet 1888 *a*, Sawerthal's. On the evening of Sept. 24th, as soon as twilight ended, it being an exceptionally fine night, I set my 16-inch on the place indicated by the ephemeris of the comet for that day. After closely scanning the field, I at length noticed a large and excessively faint nebulous object close to and a little north of six stars of about the 13th magnitude arranged in the form of two small right-angled triangles. Being so large I was in doubt, at the time, whether it was the comet or a nebula. I have had but two opportunities since to examine the spot, and on both occasions the seeing failed to equal that at the time of discovery (though one was nearly as good). I could detect nothing nebulous even with the most intense gaze, and so am inclined to think that the object seen was the comet.

Its approximate place was R. A. $23h\ 53m\ 40s + 52°\ 18'\ 40''$.

I entered it in my note-book as follows: "e e e F., L., irregularly round, two little triangles close S." LEWIS SWIFT.

Warner Observatory, Nov. 16, 1888.

Harvard College Observatory will send out a party of observers to view the total eclipse of Jan. 1, 1889. From Professor E. C. Pickering, the Director, we have obtained the following facts:

The party will consist of W. H. Pickering, Chief. A. Lawrence Rotch, S. I. Bailey, E. S. King and Robert Black. Mr. Rotch has already more than a national reputation as a meteorologist and it will be in that line that his service will be rendered. The other three have been for some time past active assistants at the Observatory and are well practised in the manipulation of apparatus and familiar with the working methods of the institution.

The study of the eclipse will not include any direct visual observations, though a single telescope for visual purposes will be taken and may incidentally be serviceable. Photographic and photometric observations and those of the spectrum will be the chief aim. The principal instruments will be the 13-inch Boyden telescope, the 8-inch Boyden, the 8-inch Bache, a 5-inch telescope, a quadruplex spectroscope,

a quadruplex photographing telescope, a spectroscope constructed with quartz lenses and prisms of the same material, and an instrument recently devised at the observatory known as the reversing-layer spectroscope.

The last-named instrument is designed to be put into service 10 seconds before totality, to continue during totality and for 10 seconds afterward. By this will be obtained a photograph by which the reversal of the rays of light, observed formerly by Professor Young, and other reported phenomena, may be determined in respect to their character.

The quadruplex spectroscope is so constructed that eight tracts or areas of the corona may be photographed at once, all these photographs dealing with the yellow and green regions of the spectrum. Another instrument photographs the blue regions, and the instrument provided with lenses and prisms of quartz will take the ultra-violet regions.

The two eight-inch telescopes will be employed in the photographic work of the outer details of the corona. One of these, the Bache instrument, has a rapid lens and the Boyden of the same aperture having a longer focus will operate more slowly, or, in other words, the negatives used will be given a longer exposure. As both are powerful instruments and operate upon the same region, which may be called the outskirts of the sun, one or the other might detect and record the inter-Mercurial planet, if, as some are disposed to think, such an one exists.

The five-inch telescope, having a focus of 7½ feet, will be employed in photographing the inner corona for measurements of light, which operation will comprise the brightness of the protuberances.

Many instruments of subordinate service are comprised in the equipment. Among these are a five-inch and a four-inch photographing camera of the ordinary kind. These worked with quick plates will be used for picturing the sky of the outer region of the corona and the sky at a distance from the sun. One of these will be operated at a considerable height above that of the observing station of the party. Each produces an image of ¼ inch diameter.

The other quadruplex instrument mentioned above is for measuring the brightness of the corona and is an ingenious piece of apparatus, a primary feature of which is a perforated plate having perhaps 1,000 minute apertures for the passage of separate shafts of light, any one of which may be used for the purpose of observation. An important part of the work will be photography of the spectrum, for which very complete apparatus is provided.

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18. On page 410, of the MESSENGER the distance of α Centauri is given as less than one-half that of 61 Cygni.

Have not later observations shown this to be wrong, and that the two are nearly the same distance?

The following table, taken from the proof sheets of Professor Young's new Astronomy, gives, doubtless, the best results concerning the parallaxes of the two stars:

Name.	Authority.	Date.	Method.	Parallax	Distance Light-Years.
				″	
a Centauri	Henderson	1842	Mer. Circle...	0.913	3.60
	Maclear	1851	Mer. Circle...	0.919	3.50
(Probably best)..	Gill and Elkins..	1882	Heliometer...	0.750	4.35
61 Cygni	Bessel	1838–40	Heliometer...	0.348	9.40
	Pogson	1853	Heliometer...	0.384	8.50
	Johnson	1854	Heliometer...	0.397	8.20
	O. Struve	1852–53	Micrometer..	0.505	6.50
	Auwers	1863	Micrometer..	0.564	5.80
	Ball	1878	Micrometer..	0.465	7.00
	Hall	1880–86	Micrometer..	0.270	12.10
	Pritchard	1887	Photography	0.433	7.55

By the term "light-year," at the head of the last column, will be understood the distance that light travels in one year at the rate of 186,000 miles per second, this being a better unit for the measure of the great distances of the stars than any other. The distance of a light-year is nearly 70,000 times the distance of the earth from the sun. Since a star with a parallax of 1″ is at a distance of 3.262 "light-years," by the following formula, $D = \frac{3.262}{p''}$, the distance of any star in "light-years," (D), may be easily found if the parallax is known, represented in the equation by p''.

The measures of the two stars given above are by good authority, and yet the results differ, in some instances, greatly, so that the uncertainty of true values is very great.

Note on the Orbit of the Comet Discovered at the Lick Observatory, on Sept. 2d, 1888, by E. E. Barnard. Late observations of this comet have permitted the calculation of orbits with close approximation to the true one. One of the best determined seems to be that of M. Berberich, given in the *Astronomiche Nachrichten*, No. 2862. His elements are:

$$T = 1889 \text{ Jan. } 31.\ 14570 \text{ Berlin M. T.}$$
$$\left.\begin{aligned} \omega &= 340^\circ\ 35'\ 31''.8 \\ \Omega &= 357\ \ 28\ \ 41\ \ .6 \\ i &= 166\ \ 22\ \ \ 3\ \ .7 \end{aligned}\right\} \text{Mean Eq. 1888.0}$$
$$\log q = 0.258382 = (1{,}813 \text{ times the distance of the sun.})$$

The middle places are represented as follows:

Sept. 17.5	Oct. 1.5
$\Delta\lambda = -2''.8$	$+0''.7$
$\Delta\beta = -4\ .3$	$-0\ .2$

M. Berberich points out the interesting fact that the theoretical brightness (H) will exceed the brightness at discovery for the best part of a year after the date of discovery. The comet will continue visible in the evening sky till the first part of March, 1889. From April to November, 1889, it will be observable in the morning, and later, the evening sky. On May 4, it rises about 2:30 A. M. It now has an almost stellar nucleus and a faint tail about half a degree long, and is an interesting object in the smallest telescope. It can easily be found by Professor Boss' ephemeris, printed in the *Astronomical Journal* (No. 184, p. 128), which for those who do not see the *Journal*, is reprinted here.

Greenwich M. T.	Appt. α h m s	Appt. δ ° ′	log r	log Δ	Light.
1888 Dec. 1.5	2 15 42	−6 18.7	0.29474	0.0575	11.6
2.5	2 9 35	−6 29.3	9.29367	0.0619	
3.5	2 3 36	−6 39.0	0.29261	0.0667	11.3
4.5	1 57 47	−6 47.9	0.29156	0.0717	
5.5	1 52 8	−6 56.0	0.29053	0.0769	
6.5	1 46 39	−7 3.3	0.28950	0.0824	
7.5	1 41 20	−7 9.8	0.28849	0.0881	10.4
8.5	1 36 12	−7 15.6	0.28749	0.0940	
9.5	1 31 14	−7 20.7	0.28651	0.1000	
10.5	1 26 26	−7 25.2	0.28554	0.1061	
11.5	1 21 49	−7 29.0	0.28459	0.1124	9.5
12.5	1 17 21	−7 32.2	0.28365	0.1188	
13.5	1 13 4	−7 34.9	0.28272	0.1253	
14.5	1 8 56	−7 37.1	0.28179	0.1318	
15.5	1 4 58	−7 38.7	0.28090	0.1383	8.5
16.5	1 1 9	−7 39.9	0.28003	0.1449	
17.5	0 57 29	−7 40.7	0.27815	0.1515	
18.5	0 53 58	−7 41.0	0.27730	0.1581	
19.5	0 50 36	−7 41.0	0.27746	0.1646	7.7

Formation of Comets' Tails. Answer to query 14, page 412 of the last Sidereal Messenger.

The statement, I believe, originated with Mr. Faye. He has only given it as his belief unsupported by any scientific facts, and it has, as far as I know, been unquestionably and generally accepted. Had he, for instance, stated that the anomaly was electrical, astronomers might have had a semblance of reason for accepting it; but as it was blindly received no other but its author could answer A. B. C.'s query.

There are several theories for the comet's tail. Tyndall says it is due to an actinic action of the solar rays on the sensitive cometic matter, decomposing it. This would suppose the comet to have only one axial revolution throughout its orbit somewhat like the moon, otherwise the actinic decomposition of the cometary atmosphere would be total if, like other bodies, it revolved on its axis faster than once, or a simultaneous re-composition of decomposed matter, an action inconsistent with known scientific facts and cometary observations.

Roche explains that radiation and gravity are sufficient to the formation of successive aureolas that are detached from the nuclei. This would suppose two ridges, one towards, the other away from the sun; observations do not confirm this. In a paper read by the writer before the A. M. A. in March last he attributed the tails of comets to the reflection of the solar rays by the highly rarified atmosphere or cometic matter surrounding the nucleus; that the solar rays are partly absorbed passing through the hemisphere nearest and partly reflected by the one farthest from the sun.

A. J. PIGEON.
No. 30 Richmond Square, Montreal, Canada.

Great Refractor for Los Angeles. By kindness of a friend in Los Angeles we learned, at the beginning of last month, of the purpose of the University at Los Angeles to erect an Astronomical Observatory which should have a telescope of 42-inches clear aperture. The instrument is to be mounted on Wilson's peak of the Sierra Madre mountains, which is 6,000 feet high, and about 25 miles from Los Angeles. The Trustees of the University now have in hand $50,000 which belong to the Observatory funds. Dr. M. M. Bovard, the President of the University, has already visited the East in the interest of this new enterprise. As the endowment of the University is already over $3,000,000 it is probable that California may yet boast of having two observatories with longer telescopes than elsewhere in the world.

We also learned from Professor Pickering recently that the 13-inch and 8-inch Boyden telescopes would be set up in January next for a short time, on Wilson's Peak, the site of the new observatory of the University of Southern Cali-

fornia, and be operated there experimentally to try the site as a point for observation.

Comet f 1888 (Barnard). A comet was discovered by E. E. Barnard, Lick Observatory, Cal., October 31.0399 Gr. M. T., in right ascension $9^h\ 43^m\ 26.2^s$; decl. $-15°\ 18'\ 52''$. Daily motion in right ascension is $1^m\ 32^s$; in declination, $+9'$. The physical appearance of the comet is as follows: Nebulosity slightly elongated, one minute of arc in diameter, 11th magnitude in brightness or fainter, strong central condensation. The cipher message conveying the above information, consisting of twelve words, was received Nov. 1, and three words were wrong, yet the entire message was made out correctly.

The following elements were computed by J. M. Schaeberle, astronomer at Lick Observatory, from observations Oct. 30, Nov. 1 and Nov. 3:

ELEMENTS.

T = Sept. 9.45 Gr. M. T.
$\omega = 267°10'$
$\Omega = 137\ 52$ } Mean Eq. 1880.0
$i = 45\ 53$
$q = 1.1216$

During the first part of last month the comet was in the constellation Hydra, being about 10° southwest of α on the 3d, and on the 15th 5° south of λ. It is a faint object, is diminishing in light, and moving slowly to the northeast. We have no ephemeris later than Nov. 15.

Charles H. Rockwell, of Tarrytown, New York, will observe the eclipse at some point in California.

The considerable space used for notices of the coming solar eclipse leaves us without space in this number for queries and answers.

George F. Davidson and Thomas Davidson, sons of Professor Davidson, of the United States Coast Survey, will use photographic apparatus in the path of the total eclipse at the high station of Winnemucca. They will employ a telescope of 4 inches aperture and 24 inches focus.

Meteors. Two bright meteors were seen at this Obseravtory on the evening of Nov. 6th. The first was observed by me at 6*h* 14*m* Haverford mean time. It appeared considerably brighter than Venus, was of a blue color, and moved in a direction from near Zeta Herculis to near Rho Serpentis.

The second was observed by my assistant, Mr. H. V. Gummere at 6*h* 51*m*. It was probably much brighter than the one first seen, and was of a green color. It curved slightly upward at first, and then went perfectly straight in a direction from Alpha Tauri to a point one-fourth the distance between Alpha and Beta Aurigæ. At the end it broke into three fragments which glowed for a while before disappearing.

F. P. LEAVENWORTH.

Haverford College, Nov. 9.

Zeta Herculis. In the Espin Circular, No. 22, under date Nov. 9, 1888, it is said that Zeta Herculis has increased in light. Mr. Gore confirms the observation.

The following important articles, as well as others, will appear in the next number: "Saturn and His Satellites," by Professor E. S. Holden; "The Canals of Mars" (illustrated), by Dr. H. C. Wilson; "Tracing Constellations, and the Constancy of Star-Maps" (illustrated), by Professor Wm. A. Rogers.

By recent letter from Florence we are pained to learn that Professor Tempel is again obliged to leave his Observatory on account of ill health.

BOOK NOTICES.

An Elementary Treatise on Analytic Mechanics, with Numerous Examples, by Edward A. Bowser, LL. D, Professor of Mathematics and Engineering in Rutgers College. New York: D. Van Norstrand, Publisher, 23 Murray and 27 Warren Street; pp. 511.

This text book, designed for scientific schools and colleges, is not new, though we have not before had the pleasure of examining it. It had already passed through its third edition in the first two years of its history.

The general divisions of the subject matter are those usually found in the best works of the kind, and their orderly arrangement is such as to make the progress of the

student easy and natural. As might be expected the calculus is used from the first. But it is used in such a way as to encourage the student instead of discouraging him when he has, as yet, but little experience in the use of that branch as an instrument of mathematical investigation. This is noticeable in the first chapter, in getting the measure of acceleration and the integration that follows; in the second chapter, in the study of the conditions of equilibrium, and especially, in the fourth chapter, in the theme of the center of gravity whose investigations involve integration including the polar formulæ. The studies of attractive force are also instructive and might well receive extended notice. As in other works by the same author previously noticed, this contains numerous examples which will certainly serve to fix the principles well in mind, if faithfully solved by the student.

Theoretical Mechanics, by J. Edward Taylor, Head Master of the Central High School Grade and Science Schools, Sheffield. London: Messrs. Longmans, Green & Co., New York, 15 East Sixteenth Street, 1888; pp. 264.

This new elementary work is intended as an introduction to the study of theoretical mechanics, and to be helpful to those who are reading in the lines of science and art departments' syllabus for the elementary stage in the English schools. This text is said also to be sufficient for the requirements of the London University matriculation examination in this branch. The course of reading is simple and plain, and can be easily mastered by students having knowledge only of the elemental branches of mathematics. The examples under each head are numerous and make a prominent feature in the plan of the book. Teachers will be interested in examining this new book.

Books and Pamphlets Received.

Cape Meridian Observations, 1882 to 1884, under the direction of David Gill, LL. D., F. R. S., etc.

Greenwich Spectroscopic and Photographic Results, 1886–7.

Greenwich Astronomical Results, 1886.

Greenwich Magnetical and Meteorological Observations, 1886.

Annuaire de L' Observatoire Royal de Bruxelles, 1885, 1886, 1887 and 1888.

Annales de L' Observatoire Royal de Bruxelles. Tomes V and VI.

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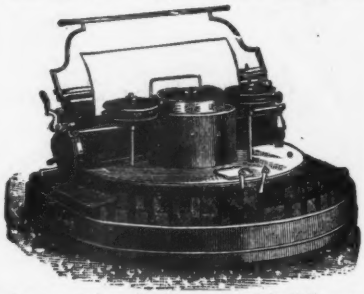

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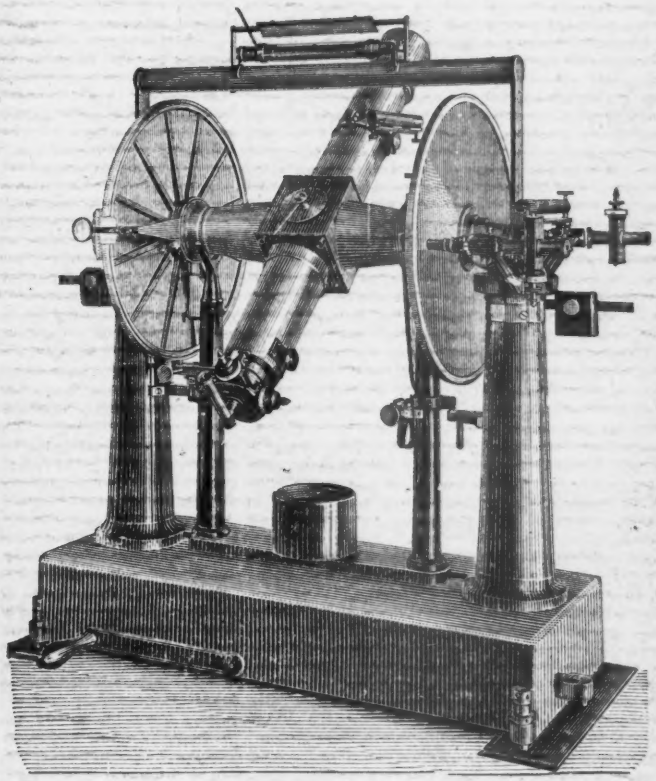

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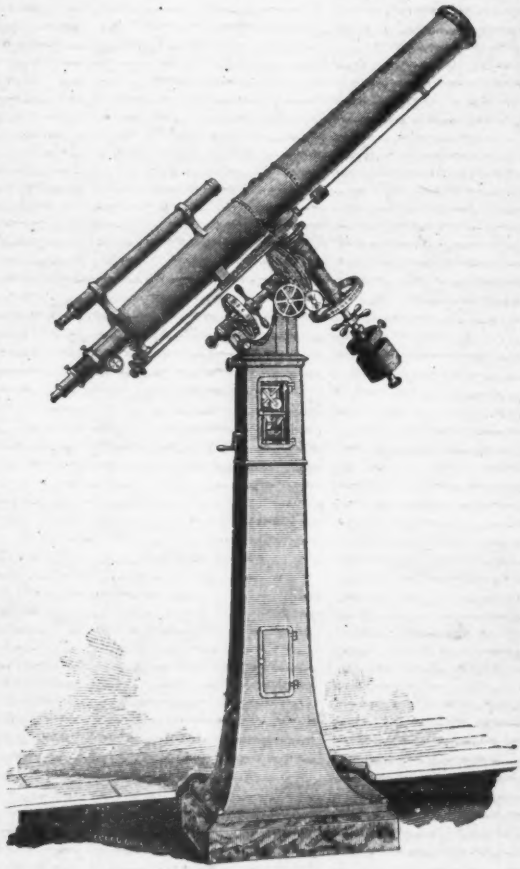

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